Spontaneous Cigarette Brand Switching: Consequences for Nicotine and Carbon Monoxide Exposure

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Abstract: A group of smokers who had participated in smoking-related studies three to six years earlier were re-studied to assess changes in their smoking practices. Individuals who smoked the same brands of cigarettes showed no change in plasma cotinine (reflecting exposure to nicotine) or expired carbon monoxide (CO) concentration. Those who switched to cigarettes of lower nicotine yield (average decrease 38 per cent) showed reduced plasma cotinine concentrations, due primarily to smoking fewer cigarettes per day. The intake of nicotine per cigarette was not different. Subjects who smoked cigarettes of higher yield (102 per cent increase) had higher cotinine and CO levels, due to greater intake per cigarette. (*Am J Public Health* 1987; 77:1191–1194.)

Introduction

The sales-weighted average tar and nicotine yields of US commercial cigarette brands, officially measured by the Federal Trade Commission (FTC), have been steadily decreasing during the past 15–20 years and appear headed toward further reduction. A desired consequence of this trend is that smoking will cause less disease. However, those who switch to lower yield brands may compensate by smoking more of each cigarette, taking more frequent and larger puffs, and/or inhaling more aggressively. Compensatory behavior could reduce or negate the expected benefits of smoking low-yield cigarettes.[1,2]

Several studies addressing this issue with mixed results have been reported in the literature.[1–14] These studies have been of two types. The first have been experimental studies comparing nicotine and carbon monoxide (CO) exposure in volunteers before and after switching, solely for the purposes of the study, to lower-yield cigarettes. This approach has several limitations: smokers change cigarette brands only for the purposes of the research; motivation and cigarette acceptability are dissimilar to the natural situation of brand switching; the studies are conducted over brief time periods.

The second approach has been to compare biological markers of exposure to compounds in tobacco smoke in current smokers of cigarettes of differing yields. Such a comparison represents a static observation of what is often a dynamic process. It does not address the natural history of smoking, i.e., whether current smokers of low-yield cigarettes had previously smoked high-yield cigarettes and, if so, whether their intake of nicotine and other components of tobacco smoke when they were smoking high-yield cigarettes is comparable to levels found in other current smokers of high-yield cigarettes. Without such evidence, one cannot assume that self-selected switchers smoke the same way as nonswitchers.

A more naturalistic way to investigate the consequences of brand switching is to sample smokers over time without experimental intervention. Subjects who have switched brands will have done so voluntarily. They choose new brands for their own reasons and find them acceptable. We took this approach in investigating changes in exposure to nicotine and carbon monoxide, which reflect tobacco smoke intake, associated with brand switching.

Methods

During the past six years, we conducted two studies in the smoking and health area.[2,15] Volunteers for these studies were healthy, regular smokers of non-menthol brands of cigarettes, who used no other forms of tobacco (pipes, cigars, chewing tobacco, snuff, non-tobacco smoking materials). Subjects had been smoking their chosen brand for at least six months. Subjects for these studies were recruited from shopping malls and through notices in community newspapers in Atlanta, Georgia, Tampa-St. Petersburg, Florida, and Westwood, New Jersey.

The objectives of these studies differed, but they had some common characteristics:

- all sampling was done between 4:00 and 8:00 pm (so that near steady state conditions of biological markers had been reached);[16–18]
- 10 minutes after having smoked a cigarette within the test center, plasma and expired air samples were obtained for measurement of cotinine and CO, respectively.

The data base from these studies provided the opportunity to recontact the volunteers and obtain a second plasma and expired air sample for comparison with previous samples.

All prior volunteers whom we were able to contact, who were still regular cigarette smokers and still satisfied health and other protocol criteria, were candidates for participation in the follow-up study. The goal was to recruit approximately 100 controls (those who had not switched brands) and as many "switchers" as possible. A switcher was defined as a smoker who had switched to a brand having a nicotine yield determined by smoking machine differing by more than 0.2 mg from his or her previous brand. Yields were taken from FTC smoking machine data reports published nearest to the date of the day of testing. A change of 0.2 mg nicotine was selected as one which might be associated with a meaningful difference in exposure.

One hundred and ninety-seven volunteers were recruited in this manner. Of these, 104 (41 men, 63 women) were controls; that is, they were still smoking cigarettes of the same FTC yields as before. Sixty-two (25 men, 37 women) had switched to lower-yield cigarettes, and the remaining 31 (11 men, 20 women) had switched to higher-yield cigarettes.

Each volunteer for the follow-up study reported to the same test center, on the same day of the week at approximately the same time of day, as he or she had done for one of the earlier studies. The volunteer smoked one of his or her

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TABLE 1—Characteristics of Subjects at Baseline

	N	Age	Fraction Males	Cigarettes Per Day	FTC Tar (mg)	Nicotine (mg)
Not Retested	610	36.0 (35.0–36.9)	0.49	32.6 (31.8–33.5)	10.5 (10.1–11.0)	0.78 (0.75–0.82)
Retested						
Controls	109	41.8 (39.7–43.8)	0.38	32.2 (30.6–33.8)	11.4 (10.4–12.5)	0.84 (0.78–0.91)
Decreasers	62	42.0 (39.1–45.0)	0.40	32.9 (30.6–35.2)	14.7 (13.4–16.0)	1.09 (1.01–1.17)
Increasers	32	40.2 (36.0–44.3)	0.34	31.9 (28.1–35.7)	4.5 (3.1–5.9)	0.42 (0.33–0.52)

( ) 95 per cent Confidence Intervals

own brand of cigarettes. Ten minutes after completing the cigarette, expired and tidal air and venous blood samples were taken.

The expired air sample was immediately measured for CO concentration using a carbon monoxide analyzer (Ecolyzer, Energetic Sciences, Inc.) with a full-scale sensitivity of ± 1 PPM. Blood samples were drawn for measurement of cotinine concentration. Cotinine, the major metabolite of nicotine, has been widely used as a marker of daily nicotine consumption,[16] which is proportional to tar exposure.[19] Cotinine levels were determined on coded samples using gas chromatography as described by Jacob, *et al.*[20] Data were analyzed by analysis of variance.

Results

The characteristics of subjects at the time of initial testing are shown in Table 1. The groups which were retested were older and had a smaller percentage of men at the time of initial sampling. Groups smoked similar numbers of cigarettes but decreasers smoked lower and increasers higher tar and nicotine yield cigarettes than controls or the non-retested population.

Changes in average FTC yields and in outcome measures were similar for men and women, so data are presented for genders combined. At retesting, there was no change in nicotine yields in controls (0.83 versus 0.82 mg); nicotine yields decreased by 38 per cent (1.09 to 0.68 mg) and increased by 102 per cent (0.42 to 0.85 mg) in decreasers and increasers, respectively.

Cigarette consumption decreased very slightly for controls (−1.9 cigarettes/day, 95 per cent CI: −3.4, −0.2) and increasers, −1.8 (−0.6, 1.1), but substantially for nicotine yield decreasers, −6.6 (−9.6, −3.5).

At initial testing, plasma cotinine and expired CO values were lowest for increasers (Figures 1 and 2). At retest, controls showed no change in plasma cotinine while decreasers showed a 19 per cent decline and increasers a 23 per cent rise in mean values. Average expired CO values decreased in decreasers but were not changed for controls.

To determine whether the change in exposures was due to smoking a different number of cigarettes or consuming different amounts of smoke per cigarette, we compared the ratio of plasma cotinine and expired CO to the reported number of cigarettes per day (Figures 1 and 2). Decreasers and controls demonstrated only slight change, while increasers showed a substantial increase in both plasma cotinine (69 per cent) and expired CO (30 per cent) per cigarette.

Discussion

The aim of the study was to investigate the consequences of cigarette brand switching without experimental intervention. Our sample is not representative of the population of smokers in the United States. For example, it includes a higher percentage of women and (although this history was

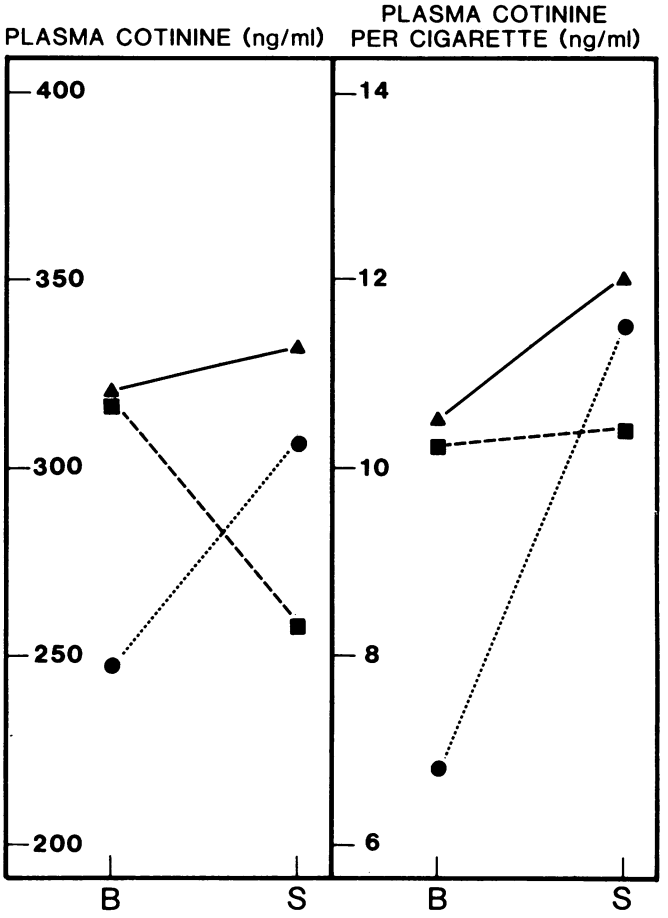

FIGURE 1—Plasma Concentrations of Cotinine and Cotinine Concentration Normalized for Cigarettes Smoked per Day in Groups at Baseline (B) and at Follow-up Study (S)
Symbols: ▲ = controls; ■ = decreasers; ● = increasers.
95% confidence intervals for differences between baseline and follow-up conditions for plasma cotinine: controls, −9, 39; decreasers, −93, −27; increasers, 13, 94; for plasma cotinine per cigarettes per day: controls, 0.3, 2.6; decreasers, −1.2, 1.5; increasers, 1.4, 5.9.

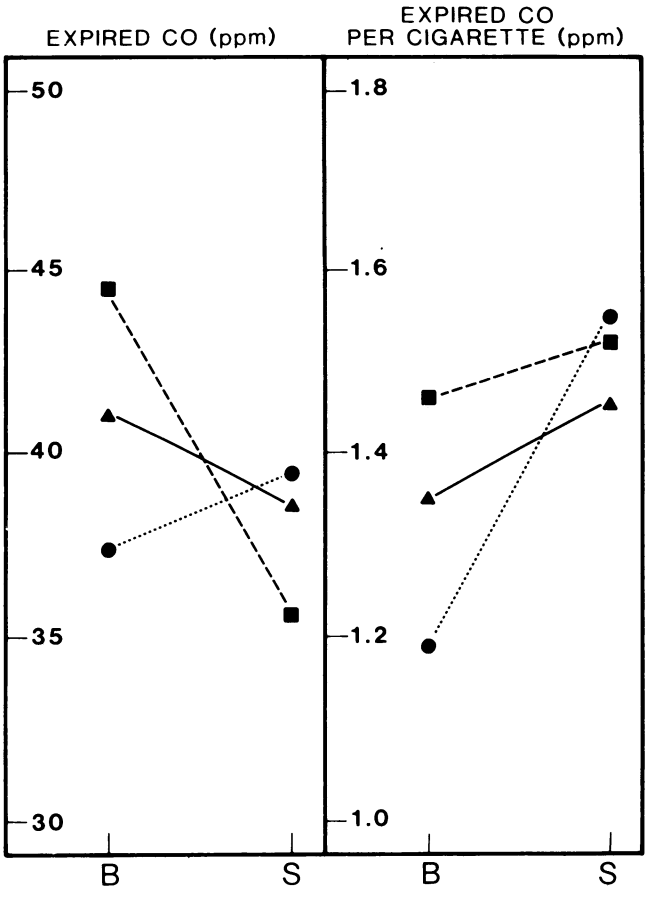

FIGURE 2—Expired Air Carbon Monoxide (CO) Concentration and CO Concentration Normalized for Cigarettes Smoked per Day
Symbols are as described in Figure 1.
95% CI for differences between baseline and follow-up conditions for expired CO: controls, −5.6, 9; decreasers, −14.5, −3.9; increasers, −5.2, 9.2; for expired CO per cigarette per day: controls, −0.4, 0.26; decreasers, −0.20, 0.33; increasers, 0.01, 0.71.

not obtained) probably a lower percentage of full-time employed people. At the initial testing, the population data were similar in age and gender to one other large population study of smokers in the United States in which participants were recruited at blood banks.[21]

The retest groups were older and contained a higher percentage of females than the original group, but cigarette smoking characteristics for non-retested subjects and controls were similar. Analysis of change in various groups showed no gender effect, so we have no reason to expect that different gender composition of groups influences the results of the study.

Nevertheless, our study group provides a unique opportunity to examine the consequences of spontaneous brand switching in a more naturalistic context and with a relatively large sample size. The observation that decreasers smoked higher-yield and increasers lower-yield brands compared to controls prior to switching was to be expected, because of the selection criteria.

Although decreasers had reduced cotinine levels, most of the decline in cotinine was due to smoking fewer cigarettes rather than consuming less nicotine per cigarette. The reasons for smoking fewer cigarettes are unknown to us. That the intake per cigarette did not change is consistent with the idea that smokers can maintain nicotine intake when switched to lower-yield cigarettes. However, it is important to note that smokers did not fully compensate for smoking fewer cigarettes, so that overall exposure did decline.

Switchers to higher-yield cigarettes had higher nicotine and CO exposures, due primarily to an increase in the intake per cigarette, although that increase was proportionally less than the increase in FTC yield. These subjects had been smoking lower-yield cigarettes and had lower cotinine and CO exposures than other groups before switching. Exposure levels after switching were similar to those of control subjects. Our results differ from some studies of heavy smokers who, when switched (for the purposes of the experiment) to high-yield cigarettes, compensated by consuming less per cigarette.[17,22] However, another experimental switching study did find that nicotine and carbon monoxide levels were higher after switching to higher yield cigarettes,[23] which is consistent with our observations in spontaneous switchers to higher-yield cigarettes.

Assuming that plasma cotinine, reflecting intake of nicotine and tar, is an indicator of potential health hazards of smoking, we conclude that, for spontaneous switchers, switching to low-yield cigarettes may be associated with diminished health risks only if fewer cigarettes are smoked. Moreover, even after smoking fewer cigarettes, exposure levels were still considerable in the group studied.

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